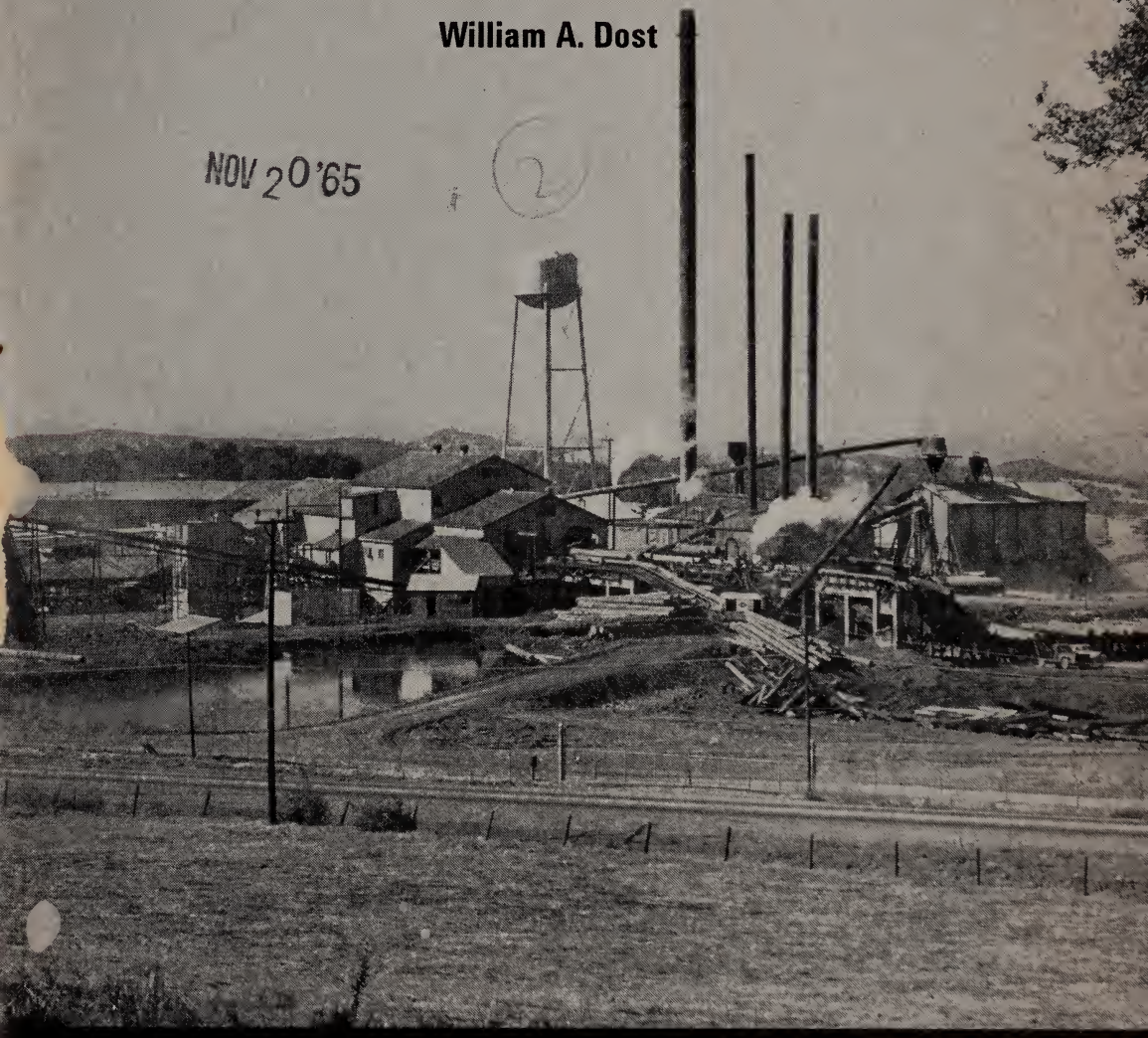
Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

WOOD RESIDUE USES IN THE CALIFORNIA PINE REGION

William A. Dost

NOV 20 '65



CALIFORNIA AGRICULTURAL EXPERIMENT STATION

BULLETIN 817

The forest products industry throughout the West, and particularly in California, is undergoing rapid changes in technology, processes, and structure. One reason for these changes is the increased application of technology in all industries, but other reasons are undoubtedly more important—prime timber is becoming less available and competition with other materials for markets is more intense. New products and processes have enabled alert and aggressive firms to bargain for timber supplies on an advantageous basis since they are in a position to utilize a greater portion of the log brought in from the woods. As time passes, both size and quality of the available timber will decrease and a greater and greater part of the log will be lost to residues. Use of these residues will become increasingly necessary.

This bulletin evaluates alternate uses for residues. It deals with raw material requirements, capital requirements, processing and other pertinent data. It does not intend to give a processor all the information he needs in order to decide on a given process, but it should help him eliminate some processes as unsuited to his particular operation. He can then study the more promising alternatives in more detail. Unique uses for wood residues were not a goal in the study.

The available literature was reviewed to find the major uses for wood residues that have been successful in the past. As a result of this review the following applications are evaluated in this bulletin:

Particleboard 3
Wood chips 7
Wood flour 8
Wood particle molding 11
Molding pulp products 13
Horticultural bark 15
Sawdust soil conditioners 16
Charcoal 17
Miscellaneous products 20

A method of residue determination was evaluated on residues from two sawmills and one remanufacturing plant in the California Pine Region; the method and results are presented in the Appendix, page 21.

THE AUTHOR:

William A. Dost is Extension Forest Products Specialist, Agricultural Extension, Berkeley.

ACKNOWLEDGMENT

The author is indebted to the Cal-Ida Lumber Company for its support of this study and for making available data necessary to it; and to Robert Kundrot for assistance in the field study and the survey of literature. F. E. Dickinson and H. C. Sampert were particularly helpful with their suggestions.

OCTOBER, 1965

WOOD RESIDUE USES IN THE CALIFORNIA PINE REGION[1]

PARTICLEBOARD

The particleboard industry continues to grow rapidly. Yet it is plagued by excess capacity and declining prices. Technology is still developing fast and the higher-quality boards are accepted most readily in the market.

The minimum economical plant in the West requires 50 tons of raw material per day; the optimum, 100 tons or more. However, past experience shows that any plant at less than optimum at the time of construction will have difficulty remaining competitive for an extended period. The most desirable raw material, generally speaking, is green wood of lumber trim and edging size or larger. Planer shavings may also be acceptable.

The manufacture of particleboard is often the first possibility considered by a manufacturer faced with the necessity of utilizing his wood residues. The market for this material has grown tremendously since the first plant was installed in Germany in 1941 and the United States in 1945. From this beginning, production in 1957 reached 183 MM sq ft on a ¾″ basis and for 1963 was 494 MM sq ft.

There are a number of specific processes available. These are described in some detail on pages 27–34 of Graham and Parrish (1961).[2] Recent installations have heavily favored the production of a high-quality board—a multiplaten product, usually a three-layered board. Its main advantages over extruded boards are its better dimensional stability and the better surface that can be obtained. Also, multiplaten board strength is relatively uniform in all directions parallel to the surface of the board while extruded board shows distinct differences.

The extrusion process requires a lower capital investment and can operate at lower production rates, but the product's characteristics limit its market acceptance. Consequently, most of the extrusion board installations are "captive" operations in which production and use conditions can be well coordinated. Production of extruded board declined by about 10 per cent in the period 1957 to 1961.

Properties and uses

The uses for particleboard are expanding with advancing product technology. A recent study showed that 80 per cent of the particleboard produced was used by the furniture trade and as core material for the manufacture of hardwood veneer and plywood. Since that study, construction uses have increased and, in 1963, more than one-fourth of all U. S. production was used as floor underlayment. In essence, particleboard is used as an alternate to lumber or plywood. Here, briefly, are the properties required of a competitive board:

- Hardness—at least equal to the material it might replace.
- Density—comparable to solid wood, at most no more than 25–35 per cent higher. The most desired boards are in the range of 40–42 lbs/cu ft.
- Stiffness—sufficient to prevent warpage of veneered panels.
- Bending strength—must be adequate for the intended use.
- Creep resistance—equal to lumber under reasonable loads.
- Tensile strength perpendicular to board surface—should be adequate.
- Dimensional stability—better than lumber of equal dimensions.
- Flatness—no tendencies to warpage.
- Smoothness—should not "telegraph" through crossbands and veneers.

[1] Submitted for publication September 4, 1964.

[2] References refer to the selected bibliography at the conclusion of each section.

- Gluability—bonds to veneer must be strong enough so that failure occurs within the particleboard. However, low-strength veneers should rupture internally before the particleboard or the glue line. Must permit edge-gluing, banding and veneering by the same methods used with lumber and plywood.
- Finishing—should accept all types of paints, stains, shellacs, varnishes, and waxes.
- Machining—should be easy to machine and permit use of carbon steel tools.
- Fastening—should permit use of screws in both edge and face, as well as the use of nails.

Manufacture

The particleboard production process is described in some detail in Graham and Parrish (1961). Briefly, it includes reducing the wood to the desired size, drying, mixing with adhesive and other additives, forming into a mat, and pressing. Newer plants usually incorporate a refinement in the mat formation step which results in a board with fine particles on the surface.

Investment

Capital investment requirements depend both on the process selected and the operating capacity. The extrusion process should only be considered for a "captive" plant. The optimum size for a multiplaten process is from 20 MM to 40 MM sq ft of ¾" board/year. In the West in 1962, four plants operated with a capacity of less than 10 MM sq ft/year, three between 10 MM and 20MM and eleven from 20 MM to 60 MM sq ft/year. The trend is clearly toward larger operating units. 100 tons/day is equivalent to 20 MM sq ft/250-day year of 40 pcf ¾" board.

The table below presents capital costs, either estimated or reported, for particleboard installations of different sizes for several years. A prominent particleboard plant engineering and construction firm indicates that, in 1963, in very general terms a reasonably efficient plant did not cost more than $20,000 per ton of daily output.

In recent years, minimum economical size has been suggested as ranging between 35 and 50 tons output per day or roughly 10 MM sq ft per year. However, western plants are generally larger than this, the trend appears to be to still larger plants, and a high mortality rate exists in the industry. Consequently, a plant should be planned not simply for profitability under current operating conditions but also should anticipate future changes. For example, a recently constructed plant has a 60 MM sq ft capacity.

Raw Material Requirements

Minimum raw material requirements are about 50 tons per day. In the West, an installation of less than 100 tons output/day should be considered unusual under present conditions.

Particleboards are made from a spectrum of wood residues ranging from dry sawdust to green solid wood. In general, dry wood residues do not make as high quality a product as do green residues;

Estimated Capital Costs

Size	1955	1956	1959	1960	1961	1962
MM sq ft	Thousand dollars					
5	...	...	550	.....	.....	.....
7	507	...	...	.....	850	.....
8	...	...	650	.....	.....	.....
10	...	705	800	.....	.....	.....
12	...	...	900	.....	.....	.....
15	...	...	...	.....	1,600	.....
20	...	...	...	3,000	2,000	.....
25	...	...	...	.....	.....	6,000*

* Total capitalization.

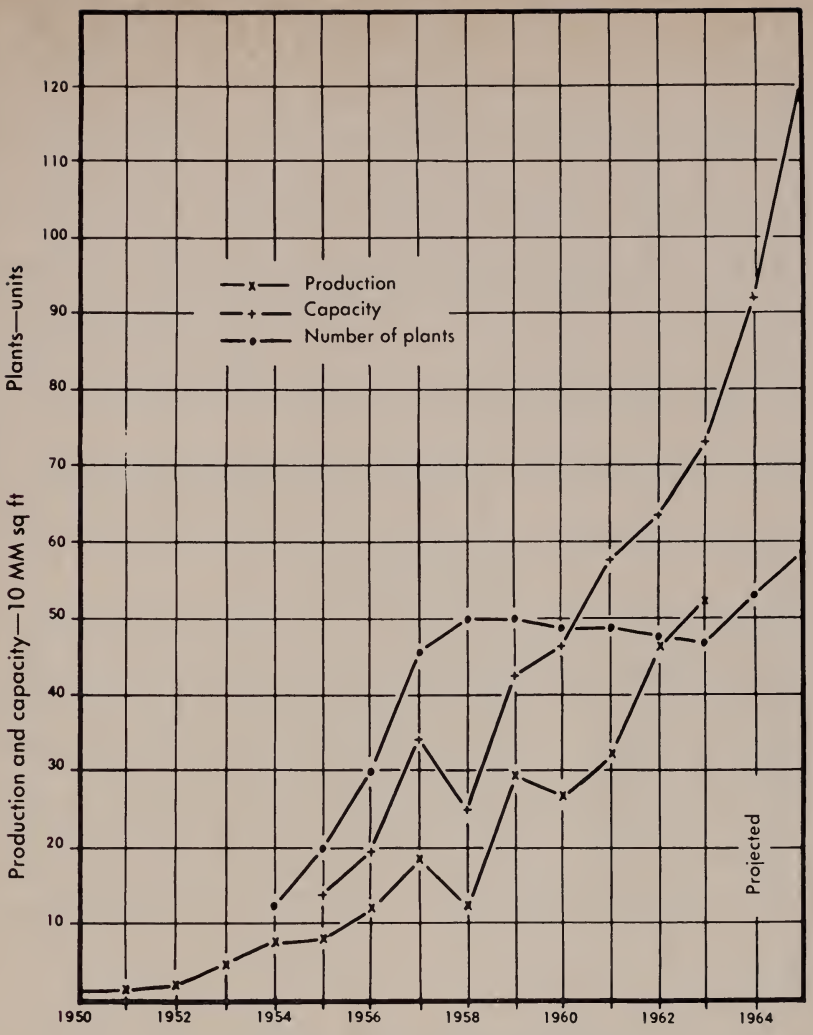


Fig. 1. United States particleboard production.

and edgings and trims or larger pieces are preferred to fine pieces.

Marketing

The rate of expansion in the industry has been explosive and there seems to be no sign of a leveling off. But other factors, too, enter the marketing picture. Figure 1 shows the relation between production capacity and actual production. Much of the unused capacity is no doubt in captive plants or is obsolescent. However, its existence combined with the turnover in operating firms indicates that the technology is still developing fairly rapidly and that competitive pressures are high.

Recent price trends (figure 2) show a decline but a substantial portion of this may be ascribed to improved manufacturing techniques resulting in lower production costs. The price picture emphasizes the necessity of designing new plants for adaptability while holding production costs as low as possible.

Freight rates represent a substantial fraction of the total price to the customer, $46/M sq ft ¾″ bd delivered to the East Coast. Therefore, the location of a plant with respect to its competitors and its markets is of utmost importance.

Each manufacturer of particleboard for the competitive market seems to provide

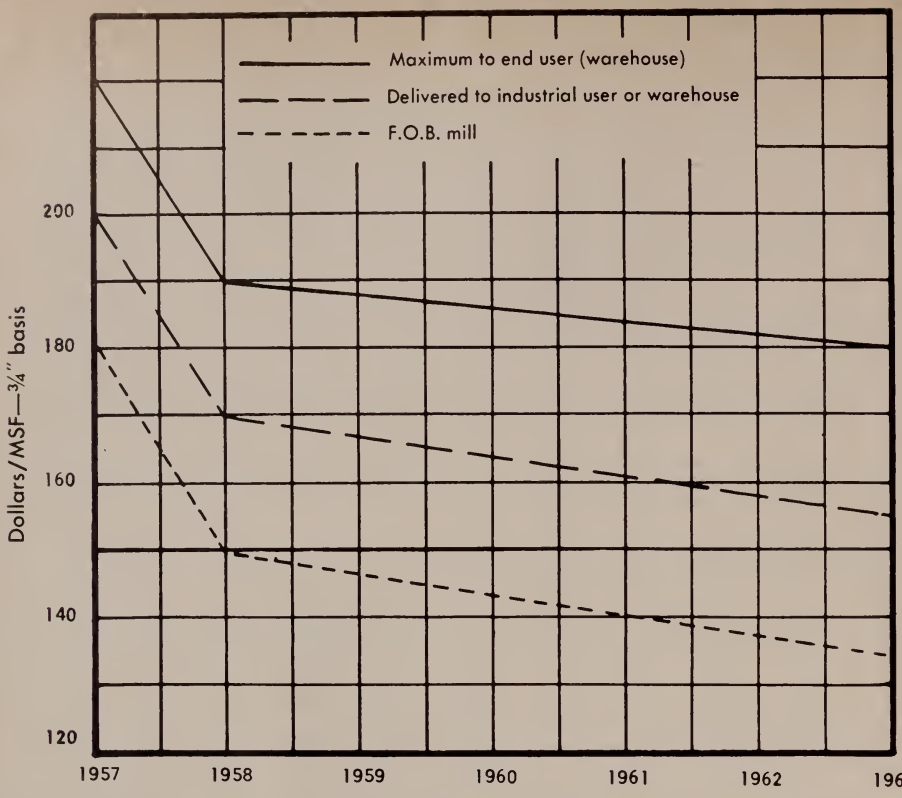


Fig. 2. Approximate price movement, medium-density particleboard. Source: Purifoy, 1963.

technical service in one form or another to its customers. There are indications that this technical service is becoming increasingly important and intensive. Most frequently, it takes the form of technical personnel located in the consuming areas.

References

Anonymous

1958. Wood particle board. White Plains, N.Y., Reichhold Chem. Inc., RCI Bldg.

1960. Particleboard. Vancouver, Sandwell and Company, Ltd., B.C. Development Memo. **12.09–16.**

1961. Current industrial reports—particleboard. Washington, D.C., U. S. Dept. of Commerce.

1962. Particleboard industry—facts and references. Lafayette, Ind., Coop. Ext. Serv. Purdue Univ. Mimeo. **F-42.**

1962. Particleboard industry outlook for 1963 and review. Washington, D.C., U. S. Dept. of Commerce.

Chiang, T. I.

1959. Wood particle board—a manufacturing opportunity in Georgia. Atlanta, Ga., Georgia Inst. of Tech. for Georgia Dept. of Commerce (March).

Graham, P. H.

1961. Particle board—its development, processes, properties, markets. Hitchcock's Wood Working Digest **63**(4):30–35.

Graham, P. H., and F. T. Parrish

1961. The economic possibilities of wood particleboard manufacture in Maine. Augusta, Me., State of Maine Dept. of Econ. Dev. (June).

Johnson, E. S., editor
1956. Wood particleboard handbook. Raleigh, N. C., North Carolina State College, 303 pp.

Kay, I. B.
1959. How profitable is particle board? Pulp and Paper Mag. of Canada, Tech. Sec., P. T. 199 (July).

Marra, G. C.
1958. Particleboards—classification and composition. For. Prod. Jour. 8(12):11A.

Purifoy, W .R.
1963. Charting particle board's road to prosperity. Wood & Wood Prod. 68(9): 41–44.

Schwartz, H., and F. W. King
1961. Use of wood and wood residues in production of fiberboard and particleboard. Ottawa, Canada. For. Prod. Res. Branch. Tech Note 31:1–16.

Smith, C. L.
1962. The growth of the particleboard industry. Washington, D.C., U. S. Dept. of Commerce, Construction Rev. 8(11):8–10.

WOOD CHIPS

The consumption of wood chips for pulp and paper manufacture in California can be expected to increase tremendously within the next few years. Mills now planned or under construction within the State will approximately triple the current rate of wood consumption for pulp. The industry also competes with hardboard and particleboard for the same raw material. Combined with the decline in the number of operating sawmills reported by the Pacific Southwest Forest & Range Experiment Station, these pulp installations portend an increasing competition for mill residues. As prices increase, chip production will become feasible at smaller mills. Chip yields ranging from as low as 0.25 unit/MBF of logs processed to as high as 0.75 unit/MBF have been reported.

Properties and uses

High-quality wood chips are used for both paper and hardboard. Also, particleboard plants operate on particles produced from similar residues. To be suitable for these uses, the chips must be of "engineered" dimensions. They must be screened to remove fines and oversize chips, and bark and decayed wood must be held to a minimum. Dirt and charred wood are not acceptable.

Manufacture

The manufacture of wood chips begins at the debarker, before the logs enter the mill. If a debarker is not available, then bark-free pieces must be picked by hand from the refuse conveyors and fed to the chipper. After passing through the chipper, the chips are screened to remove the over- and undersized pieces. The fines and oversized pieces are discarded. Chips are then ready for shipment.

Capital investment

The reported costs of one installation for the production of wood chips from sawmill residues are as follows:

Sawmill barking and chipping plant including installation

Structures	$43,000
debarker (34″ ring type)	64,000
debarker transfers, conveyors, etc.	33,000
Chipper	19,000
Chipper conveyors, screens, etc.	18,000
Chip loading and compaction	27,000
Total cost	$204,000

In addition, it would be necessary to either contract for or purchase the necessary trucks for delivery of chips to a rail siding or to the purchaser if the sawmill was not located at a rail siding.

WOOD FLOUR

The production of wood flour appears to require art as well as technology. Of primary importance is a good source of raw material—sawdust and shavings of the right species and moisture content. Sander dust is increasingly being recovered and used as wood flour. The product may vary from manufacturer to manufacturer, even when similar species and processes are used. The principal uses are as absorbents and fillers. It competes with similar materials from other sources and with wood flour imports. Reported prices had not changed noticeably between 1947 and 1963.

Much of the data presented in the following sections is taken from Reineke (1947).

Information on the manufacture of wood flour is difficult to obtain. Relatively few articles and reports on the subject were written before 1945. Statistics on wood flour production are limited. The U. S. Census Bureau published data during the 1930's but then discontinued the practice. Census Bureau figures show national utilization of 19,000 tons in 1935, 28,000 tons in 1937 and 49,000 tons in 1939. Imports during this period were significant. The Western Pine Association stated that 80,000 tons were utilized in 1947 and 100,000 tons in 1950. California Forest & Range Experiment Station figures put California utilization at 21,000 tons in 1952.

Producing plants contacted expressed pessimism about future markets. On the other hand, those articles that have appeared recently have generally expressed optimism based upon projections for the consuming industries, primarily plastics molding. However, an expert in the field of plastic resins, when asked about the potential of wood flour production, suggested particleboard as a more promising use for residues. He pointed out that the manufacturing of molded toilet seats, a major market for wood flour, was so dominated by a few large producers that a successful entry into this market would be very difficult.

Properties and uses

Three grades of wood flour are generally recognized, Technical, Non-Technical, and Granulated or Special Purpose. Technical grade normally must pass a specified 60-mesh or finer screen and usually must be of a single species. Non-Technical grade is much less restrictive, allowing coarser particles, a wider range in particle size, and a mixture of species. Granulated or Special Purpose grade specifications are more restrictive than Technical grade. Granulated is frequently ground to a finer mesh than Technical, and the particle shape and weight are specified.

Required properties are light color, low resin content, and moisture content of 9 per cent or lower. The white pines (sugar, western, and northern) satisfy the color and resin requirements to the extent that 75 per cent of the flour produced domestically comes from these species. Other species used are spruce, poplar, birch, maple, hemlock, Douglas-fir, and cedar. While not listed as a raw material species, true firs would probably yield flour similar to hemlock.

Wood flour is generally used as:

- Absorbents
- Chemically reactive substance
- Chemically inert filler
- Modifier of physical properties
- Mild abrasive
- Decorative material

Of these, the principal uses are as an absorbent in dynamite and as a filler in linoleum and molded plastic products.

Raw material requirements

Most wood residues are unsuitable for wood flour manufacture because of species, contamination by bark or knots, or moisture content. Ponderosa pine would probably cause problems in subsequent molding because of its resin content, particularly if flour were to be manufactured from box trim ends. Sugar pine sawdust and planer shavings would make an ideal raw material source if the moisture content were sufficiently low. Douglas-fir and white fir sawdust and shavings also could be used for lower-quality flours.

No information on minimum or optimum size was found in the literature. A capacity of 1 ton per hour was the lowest production rate noted.

Manufacture

Processes—Wood flour is produced either by reclamation of sander dust or the screening of sawdust or, by attrition, hammer or roller milling. An attrition mill is an efficient method of producing most types of wood flour. The hammer mill is practically limited to flour no finer than 100 mesh because of the low mass of the finer particles. Roller mills which crush the wood are able to produce exceedingly fine flours up to 350–400 mesh size.

Two methods are used in sizing of the product. The original method uses oscillating screens much as those used for the sizing of pulp chips. Its main disadvantage is that occasionally slivers produced in hammer mills may pass through the screen. These slivers are a defect in flour for use in plastics molding. Air screening, the other method of separation, usually results in a higher percentage of fines and may also contain relatively larger broomed particles than mechanically screened flour. It appears that either method can yield an acceptable flour for most purposes. The final product is bagged or baled for shipment. More detail on wood flour production is presented in Reineke (1947).

Power requirements—Power costs increase with machine size. Production capacities of equipment vary inversely with the ratio between the meshes. At the 100 or finer mesh sizes, power consumption varies directly and output varies inversely as the square of the ratio of the meshes. Total power requirements are about 125 hp hours to reduce a ton of white pine shavings to 40 mesh while 400 hp hours are required to produce a ton of 80 mesh.

Special hazard—Fire hazard is great in a wood flour plant because of the fine particle size. Under the right conditions, air–wood flour mixtures are explosive. Because of this, every effort must be made to eliminate sources of ignition such as smoking, sparking in electrical equipment, etc. Cleanliness is imperative to minimize damage resulting from fires which do occur.

Investment

The U. S. Forest Products Laboratory report (Reineke, 1947) indicates that the equipment for the production of 1 ton per hour of 40-mesh flour would cost between $5,000 and $8,000. Attrition and roller mills are both somewhat more expensive than hammer mills but attrition mills have lower power and maintenance costs. Unit cost of the equipment is reduced for larger size machines.

Correspondence with present wood flour manufacturers indicates that the minimum investment for a wood flour plant might be as much as $150,000. However, this figure would include the buildings and accessory equipment.

Marketing

Prices reported for 1947 were $20 to $25 per ton for 40-mesh, $35 to $40 per ton for 100-mesh, and up to $85 per ton for finer meshes and special grades. Current prices for wood flour reported by present producers and users are about in the same range, $25 per ton and less for the coarser mesh material.

References

Anonymous
n. d. Wood flour. Chicago, Ill., Prater Pulverizer Co. 4 pp.

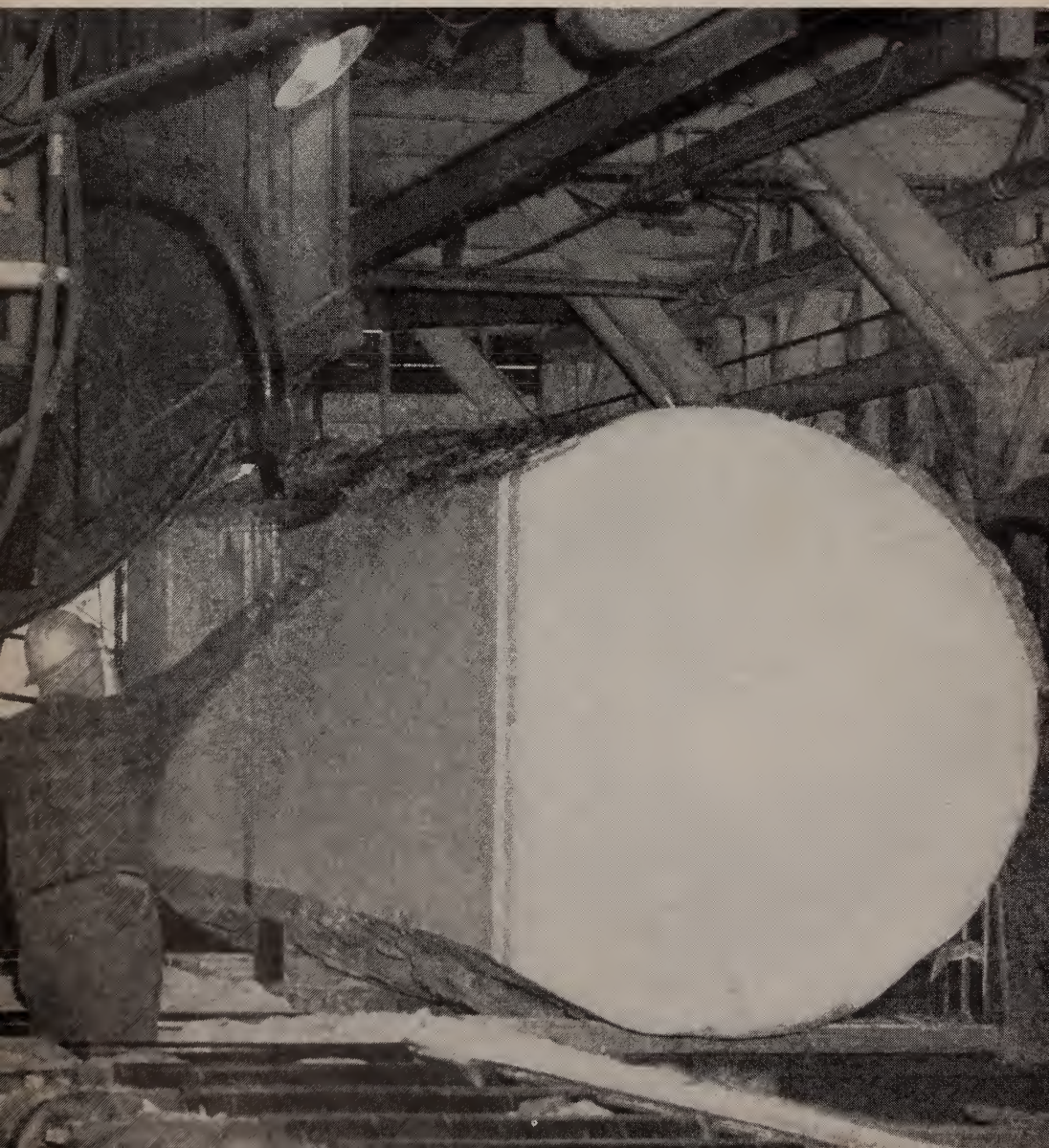
Bowen, P. P.
1957. Manufacture and use of wood flour: Wood waste. For. Prod. Res. Soc. Wood Tech. Ser. 22:47–48.

Emmett, J. A.
1938. Wood flour production: Possibilities as a profitable means of waste utilization. The Timberman 39(9):91.

Gangloff, W. C.
1963. Fillers in the plastics industry. Chem. Ind. 53(4):512.

Jahn, E. C.
1939. Wood flour market expanding. West Coast Lumberman **66**(7):40.
Reineke, L. H.
1947. Wood flour. Madison, Wisc., U. S. For. Prod. Lab. FPL No. **R1666–9.**
Seymour, R. B.
1962. Fillers for moulding compound. Mod. Plastics, 1962 Encyclopedia Issue **39** (1A):556–60.
Schulman, J. and B. L. Wilner
1960. New uses for wood flour in rigid polyurethane foams. For. Prod. Jour. **10**(10): 487–90.
Wilner, J. R.
1956. Wood flour: Past, present and future of utilization. For. Prod. Jour. **6**(8):17A.

Fig. 3. Pine log in head rig.



WOOD PARTICLE MOLDING

Whereas the manufacture of wood flour for sale on the open market does not appear to be particularly attractive in view of the essentially static price situation for the last 15 years, the limited number of available customers, and the relative remoteness of most California mills as compared with those that could be located in either Los Angeles or San Francisco, the combination of a wood flour plant plus a wood particle molding plant might prove worthwhile. However, profitable operation depends on long production runs because of the cost of molds; thus, the products to be manufactured must be selected with care. If a promising product line can be selected, this approach should be seriously considered.

The principal use for wood flour, as the basic component in molded articles, appears to be expanding. In this process, the wood flour is mixed with an appropriate amount of thermosetting resin, introduced into a heated compression mold, and pressed. The wood flour can comprise as much as 95 to as little as 50 per cent of the resin-flour mixture. Molding pressures are between 1,000 and 2,000 psi and molding temperatures are usually held below 350° F to prevent charring. The process differs from particleboard production in that hardened steel molds are used rather than flat polished plate, and the resin content is higher.

At present molded wood is used mainly for toilet seats. Other products are hamper tops, brush backs, school furniture, appliance bases, furniture parts, sporting goods handles, etc. In general, a molded-wood article might be competitive with any article made from solid wood if its production includes a substantial number of operations or if the waste factor is high. Potentially, a molded-wood article would be lower in cost and could replace a molded-plastic article if it could meet the use requirements.

Properties and uses

The properties of molded wood articles can be varied over a wide range through changes in formulation and processing. Important for the finished article are impact strength, screw holding power, water absorption, color, surface hardness, and finishing characteristics. These properties can all be manipulated by formulation. Changes in formulation also result in changes in process characteristics such as cure time and press cycle.

In general, molded wood is harder, heavier and more amorphous than natural wood. It has no grain, which eliminates weaknesses of certain types, but it also reduces the beauty of the article and the strength of the material compared to natural wood. The surface is harder and more impervious to liquids but the uncoated surface of the molded wood is less resistant to wear. The dimensional stability of molded wood under conditions of changing humidity is better than tangential or radial stability of natural woods but most woods have better stability in the direction along the grain. The molded product also has a lower rate of absorption in direct contact with water but, given time to penetrate, the water causes greater damage to the physical properties of molded than natural wood.

Manufacture

The process itself is relatively straightforward. The wood flour is introduced into the blending equipment, followed by the other materials included in the formulation. In addition to the resin, parting agents, water repellents, and pigments are often included. Blending requires 15–30 minutes when no pigment is included and 30 minutes to one hour when pigment is added. Depending upon the particular plant and equipment, the blend may then be delivered directly to the mold for pressing or it may be first preheated and prepressed. Preheating melts the resin, resulting in a better coverage of the wood particles, and also advances the resin,

reducing the cure time. Prepressing consolidates the wood-resin mixture, reducing the bulk and facilitating the mold-charging operation. Mold temperature is usually maintained between 280° and 350° F depending upon the resin used. Pressures of 500 to as high as 3,000 psi are common, and for some special shapes 4,000 to 5,000 psi are used. Molds are usually manufactured from tool steel. Specific gravity is controlled by the charge into the mold since the molds are closed to stops.

Resins used are melamine, phenol, and urea. Urea is the lowest in cost but also results in the lowest product properties, particularly water resistance and permeability. It requires a somewhat shorter press cycle. Phenolic resins are more expensive than urea but give improved water resistance and surface characteristics. Phenolic resins result in a somewhat darker molded article, which frequently is undesirable. Melamine resins are the most expensive but result in the most satisfactory properties in the end product.

Raw material requirements

Wood flour used is generally in the range of 40–100 mesh, with 80 mesh being the most common size. Where surface smoothness and appearance are not important, coarser sizes may be used with excellent results. While some references state that any species except oak may be used as a source of wood flour, hardwoods generally give somewhat different properties than do softwoods and each species differs somewhat in the results obtained.

In general, hardwoods give a better mold release and a faster cure because they have no resin, but are more expensive than softwood flour. Mechanical strength usually is somewhat lower than with softwood but water absorption and surface hardness characteristics are better. Softwood flour results in higher-strength moldings but it is more bulky, requiring deeper loading wells in the mold and complicating the charging operation. The resins in softwood are thermoplastic and act as plasticizers for the molding resin. This retards the cure rate and tends to reduce the mold release. In addition, it may result in a surface that is more difficult to finish.

Moisture content is critical. A moisture content of less than 4 per cent tends to restrict the flow of the molding mixture in the press and also to reduce strength. Moisture content higher than 8 per cent will cause blisters during the molding operation and prolong the cure.

The mixture of species cut in most pine region mills could probably be accommodated in an associated molding operation but any fluctuations in species percentage throughout the year would necessitate frequent adjustment of the molding formulation. Evidence in the literature indicates that trims from pine box manufacture would probably contain too much resin to be a satisfactory source of raw material.

Investment

Only one detailed estimate for capital investment was obtained. This estimate was for a plant processing a maximum of 40 tons of wood flour per eight-hour shift when all of the molded articles were rectangular shapes of optimum size. Allowance should be made for less than optimum shapes. This estimate follows:

EQUIPMENT

6 presses—$5,000 each (capacity 150 pcs 1″ ×2½′ ×2½′ per press hour)	$ 30,000	
Press accessories (pumps, valves, pipes, wiring, timers, etc.)	2,000	
6 molds	20,000	
Mixing equipment	4,000	
Exhaust fans and ducts	2,000	
		$58,000

BUILDING

Press operation area	1,000 sq ft
Raw material storage	750 sq ft
Finishing	750 sq ft
	2,500 sq ft
Cost at $8.00/sq ft	$20,000

CONTINGENCIES

Contingencies	$ 7,000
Grand total:	$ 85,000

POWER

Steam—6 boiler hp (120–150 psi)
Electricity—30 hp

Marketing

Molded wood products have a definite competitive area. The least expensive plastic molding materials are priced about $10 per cu ft, excluding cellular types. A wood flour molding mixture at a specific gravity of 1.0 costs approximately $3 to $4 per cu ft, roughly the same price as kiln-dried lumber. When a molded wood article can be fabricated without too much difficulty, it very likely will be competitive with the corresponding article molded out of solid plastic. When an article fabricated from solid wood requires a number of machining steps or the removal of a large percentage of the original material, the corresponding molded article also is likely to be competitive. One report indicates that, in general, if 25 per cent of the wood or more has to be cut away in a solid wood part, molding will be lower in labor cost. Beyond this, there is very little similarity between the marketing of molded products and conventional building materials. The relatively high cost of molds requires that materials to be molded be scheduled for long runs. To market molded wood products successfully, one must find articles that can be manufactured from wood flour, have advantages in properties or manufacture, and that will have extended production runs.

References

Anonymous

n. d. Granulated wood molding. St. Louis, Mo., Monsanto Chem. Co. Prod. Inf. Bul. **1027**.

1959. Wood particle binder resins: Wood flour utilization. New York, Cyanamid Tech. Data Bul. **II**, 12 pp.

Brockschmidt, K. W.

1960. Fundamentals of molding wood particles. For. Prod. Jour. **10**(4):179–83.

Donohue, F. J.

1961. Granulated wood molding. Ind. Woodworking **13**(7).

Midyette, L.

1957. Wood particle molding. For. Prod. Jour. **7**(1):1–6.

Watson, D. W.

1959. Low cost wood-particle moldings. Materials in Design Eng. 49(5):103–05.

Williams, F. H., and J. Grano

1954. The manufacture of molded articles from resin bonded granulated wood. For. Prod. Jour. 4(5):227–30.

MOLDING PULP PRODUCTS

The consumption of wood pulp for plate, dish, and tray stock has increased rather consistently during the past 15 years, as shown below (U. S. Census data). Indications are that the market will continue to expand.

Plate, Dish, and Tray Stock

Year	*Short tons*	*Year*	*Short tons*
1946	2,696	1954	65,201
1947	18,674	1955	83,404
1948	7,977	1956	87,747
1949	21,614	1957	94,841
1950	32,380	1958	99,126
1951	27,872	1959	99,286
1952	31,367	1960	116,996
1953	62,651	1961	119,014

The molded pulp industry is by nature secretive. Few useful articles have appeared in the literature and it is accepted industry practice to close plants to visitors. Consequently, the information presented here represents relatively little reported experience.

The minimum plant size is reported to be about 50 tons of product per day. The critical problems in pulp or paper production are water supply and effluent disposal.

Semi-chemical pulp has a process water requirement of 10,000 to 30,000 gallons per ton of product. The cost of a semi-chemical pulp mill without liquor recovery facilities was estimated at $20,000 to $30,000 per ton in 1954. A California installation with a rated capacity of 75 tons per day plus converting facilities reportedly cost $25,000,000 in 1956, and a recently installed California converting plant, using waste paper as a furnish, cost an estimated $10,000,000 for a 100 ton per day capacity. From these rather meager data, it would seem that the combination of process water requirements, effluent disposal and capital investment makes this approach to residue utilization relatively unattractive for most operations.

References

Anonymous

1954. Pulp manufacturing factors. Madison, Wisc., U.S. For. Prod. Lab. 89 pp.

1960. Nonplastic molded pulp products. Madison Wisc., U.S. For. Prod. Lab. Rept. **1964**(rev.).

Applefield, M.

1956. The utilization of wood residues for pulp chips. College Sta. Texas. Texas For. Serv. Bul. **49**. 121 pp.

Fogh, I. F.

1961. An evaluation of the economics of supplying sawmill (waste) chips to pulp and paper mills. Pulp Paper Mag. of Canada **62**(2):95–101.

Jacobson, Gus

1955. New developments in mechanical equipment for sawmill waste utilization. For. Prod. Jour. 5(5):35A–38A.

Otis, B.

1957. Diamond Match applies groundwood-from-chip pulping to softwoods. Paper Trade Jour. **141**(7):36–39.

Textor, C. K.

1957. Second progress report on the Bauerite process for "Groundwood" from chips. Springfield, Ohio, The Bauer Bros.

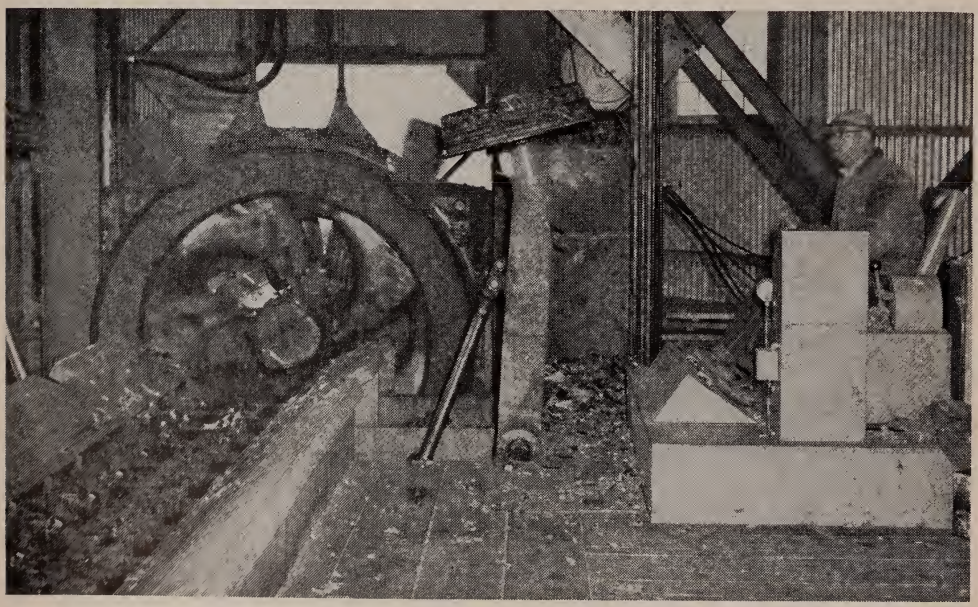


Fig. 4. By debarking logs prior to sawing, it is possible to recover both bark for horticultural markets and wood chips for pulp production.

HORTICULTURAL BARK

The use of true fir and pine bark for landscaping and horticultural purposes is increasing and demand at times exceeds the supply. Prices are held in check by the availability of other materials and by landscaping techniques. Even so, the minimum price at the mill is more than twice that received for an equivalent volume of plup chips. One mill reports a sales price of over $4.00 per yard, or roughly five times the price of an equivalent volume of pulp chips.

The other benefits of sawing debarked logs—higher production of pulp chips, greater recovery, reduced saw maintenance, and lower clean-up costs—have been well established. The attractive market for bark as well as chips suggests that debarking should be adopted if at all possible.

The field study showed that approximately 20 cu ft of fir and pine bark are generated per MBM of logs cut. A net yield of 14 cu ft/MBM after processing losses has been reported, equivalent to more than 650 cu yd/MMBM of production.

Actual statistics on the production or sale of bark for agricultural purposes seem to be nonexistent. However, an increasing number of mills, some starting more than ten years ago, are disposing of this part of their residues to an expanding market. Brokers have indicated that they could move additional quantities of bark if it were available. A Bay Area dealer in bulk quantities indicates that the market for the coarser grades is exceptionally good and expanding. Packaged tree bark for consumer trade was almost nonexistent a few years ago, but the product is now readily available at the retail level.

Properties and uses

Three generally accepted segregations of bark are ¼″ minus, ¼″ to ⅝″, and ⅝″ to 1⅛″ sizes. There is some specialty demand for 1⅛″ to 3″ size. Special-purpose grades such as orchid-culture medium also exist. The least desirable grade is the fines, and the quantity produced is generally held to a minimum. Bark to be sold as a soil conditioner is often pulverized and composted first. Nitrogen is added to speed the process. Cutter-head barkers can produce only fine material, which may be composted although the relatively large percentage of wood contained makes nitrogen requirements higher.

Barks of the pines and true firs are generally preferred. Douglas-fir bark contains short fibers which cause skin irritation, and is acceptable only in restricted markets.

Manufacture

The production of horticultural bark is relatively simple. The bark is first removed from the log, screened to remove sawdust and dirt, broken down to the desired size and rescreened. Oversize particles are recycled back through the hog and screen. As previously mentioned, fines are held to a minimum and freedom from wood particles is important. Processing costs of 55 cents per yard or $4.15 per unit are reported for an efficient operation.

Because of the market demand for the larger sizes, a ring-type debarker is most satisfactory. Screens of the oscillating type similar to those used for pulp chips are best but trammel screens appear to be adequate and cheaper in initial cost. Following screening, the bark is delivered to storage bins.

Investment

Generally, the production of bark is coupled with the production of pulp chips, and investment charges properly should be divided between the two. Principal items required for bark production, exclusive of a debarker, are conveyors, hog, screens, and storage. For a plant processing 75 M to 150 M bf/day, this probably would cost between $20,000 to $30,000 although some installations at two to three times this cost have been reported. In addition, space for composting or bulk storage of accumulated inventories is usually necessary.

Marketing

Market prices reported for bulk quantities at the mill were a low of $.50 per cu yd for bark sold to processing plants to as much as $5.50 per cu yd for fully processed bark, the equivalent of $3.70 to $40.75 per unit. Bark is sold in some cases to other mills or processors that have a marketing organization, in some cases to brokers, and in some cases to distributors. Shipments are usually made by truck, and the major markets are in the Bay Area and Los Angeles. Bark weighs 500–800 pounds per cu yd and transportation comprises a substantial part of the delivered price.

References

Baker, K. F., editor
1957. The U. C. system for producing healthy container-grown plants. Univ. of California Manual 23.

Bollen, W. F., and D. W. Glennie
1963. Fortified bark for mulching and soil conditioning. Oregon State Univ. Agr. Exp. Sta. Tech. Paper 1665.

Dunn, S.
1956. The influence of waste bark on plant growth. Univ. of New Hampshire Agr. Exp. Sta. Bul. 435.

Ivory, E. P.
1958. Yields and preparation of bark from a medium sized sawmill. N. Calif. Sect., For. Prod. Res. Soc. Proc. (May, mimeo.)

Kohl, H. C.
1958. Use of bark for soil improvement. N. Calif. Sect., For. Prod. Res. Soc. Proc. (May, mimeo.)

Lunt, O. R., and B. Clark
1959. Horticultural applications for bark and wood fragments. For. Prod. Jour. 9 (4):39A–42A.

SAWDUST SOIL CONDITIONERS

Considerable volumes of redwood sawdust, and to a lesser extent Douglas-fir and other species, are used as a mulch or soil conditioner in landscaping and floriculture. This use is well established and acceptance is increasing. Studies seem to indicate that most other species (at least most other softwoods) could be used also.

Sawdust has been used as a soil conditioner for many years and numerous publications have been written on the subject. Until quite recently, however, high-quality sphagnum peatmoss was available at a reasonable price, and the established practice of using peatmoss restricted the use of sawdust. As quality peatmoss becomes more expensive and sawdust-use techniques become more widely established, acceptance is increasing.

Organic material in the soil improves plant growth by improving water-holding capacity, aeration, and tilth; as it disintegrates, it adds humus to the soil but loses most of its aerating and water-holding ability. In the process, it also ties up nitrogen. This nitrogen drain is heaviest shortly after the application of fresh sawdust. There is also some evidence that fresh sawdust may contain some toxic chemicals, making a composting or leaching period desirable.

Manufacture

Sawdust is usually screened to remove larger pieces of wood. It may then be sold in bulk, sacked as raw sawdust, or composted before sale. Chemicals are frequently added to counteract the nitrogen drain; this product may then be sold immediately or after composting. The species most frequently sold is redwood; where other species are sold, they are generally kept separate.

Investment

No information was available on established plants. Required are a method of collection of the sawdust, a simple screen, and adequate space to stockpile large amounts because sales are seasonal. A system for truck loading of bulk sales is needed, and one for sacking if package sales are planned. Metering and mixing equipment is necessary for the addition of chemicals.

Marketing

Almost all shipments are made by truck. Most frequent are bulk sales at the mill and the operator has no further interest in the distribution system. Some mills consign their production to a processor who handles the distribution but most sell on a first-come-first-serve basis. Uusally bulk sales are marketed through landscape contractors and nurseries; package sales through nurseries and chain stores.

References

Allison, F. E., and M. S. Anderson
1951. The use of sawdust for mulches and soil improvement. Washington, D. C., USDA Cir. **891.**

Allison, F. E., R. M. Murphy, and C. J. Klein
1963. Nitrogen requirements for the decomposition of various kinds of finely ground woods in soil. Soil Sci. **97**(3):187–90.

Anderson, M. S.
1957. Sawdust and other natural organisms for turf establishment and soil improvement. Washington, D. C., USDA Agr. Res. Serv. ARS **41–18.**

Bollen, W. B., and D. W. Glennie
1961. Sawdust, bark and other wood waste for soil conditioning and mulching. For. Prod. Jour. **11**(1):38–46.

Gessel, Stanley P.
1959. Composts and mulches from wood waste. Univ. of Washington Inst. of For. Prod. Cir. **33.**

McIntyre, Arthur C.
1952. Wood chips for the land. Washington, D. C., USDA Soil Cons. Serv. Leaf. **323.**

Richards, S. J., J. E. Warneke, A. W. Marsh, and F. D. Aljibury
1964. Physical properties of soil mixes. Soil Sci. **98**(2):129–32.

Wilde, S. A.
1958. Marketable sawdust composts: Their preparation and fertilizing value. For. Prod. Jour. **8**(11):323–26.

CHARCOAL

The consumption of charcoal is rising steadily, but the selling price has declined and only about 40 per cent of the production capacity was used in 1961, the latest year for which data are available. About 3⅓ units of wood are required to produce 1 ton of charcoal from softwoods. At the current price of pulp chips, raw material costs would be $20 to $21 per ton of product; conversion costs would add about $10 to $14 per ton depending upon equipment. With a selling price of $35 per ton for charcoal fines, it can easily be seen that charcoal producers cannot compete with pulp mills for raw material.

Charcoal production may be attractive, however, as a use for residues unsuitable for pulp production. This includes bark, unbarked wood, sawdust, and shavings. Using this type of material, a charcoal operation could approximately break even at a $7 per unit raw material price. If combined with a briquetting plant, an efficient overall operation should be profitable. Briquetting costs run about $20 to $30 per ton and the selling price of briquettes is about $75 to $90 per ton.

Many charcoal producers are inadequately financed, and therefore unable to in-

ventory production through the winter for sale in the spring. A firm not handicapped in this fashion would have a considerable advantage over competitors. Automated continuous charcoal production would seem an attractive possibility because production is heavily concentrated in the eastern part of the country, markets are local, and batch-type operations are mostly rather inefficient. The disadvantages are the large raw material requirements and the fact that charcoal production cannot compete with pulp production for raw material.

Charcoal is one of the oldest of manufactured products. It has been used both as domestic fuel and in industry. Industrial uses have become less important and domestic uses, particularly for outdoor cooking, now dominate the market. The industrial uses that have remained important are primarily the various applications of activated charcoal for purification purposes. Production statistics and import-export trade are presented in Anon. (1963), tables 1 and 2. Price information is presented in table 11 of the same publication. The data indicate that 98 per cent of the charcoal is produced east of the Rocky Mountains. Consumption figures are not available but because of the recreational activity in a mild climate it seems logical to expect that California's per capita consumption, at least for domestic purposes, would be above the national average. Much of the charcoal consumed in California, therefore, is imported from the East.

At the present time, most charcoal is produced from cordwood either in batch-type kilns, where the products of combustion of the charge itself are used to supply the heat for carbonization after an initial start-up period, or by batch-type retort where the heat of carbonization is provided by an external source. Recently, a number of pieces of equipment for continuous operation, using sawmill residues, have been developed. Only the continuous process is considered in this report.

Hardwood charcoal is preferred but softwood charcoal is saleable.

Properties and uses

Industry uses about 10 per cent of charcoal production, mostly for metallurgy and purification processes such as sugar refining. California consumption of wood charcoal for industrial purposes in 1961 was negligible.

The principal quality requirement for most charcoal is that it contain more than 80 per cent of fixed carbon. Activated carbon usually has fewer impurities and a greater percentage of fixed carbon, and has been treated to increase its adsorptive capability.

Raw material requirements

The minimum operating capacity for a continuous charcoal operation seems to be about 10 tons of charcoal per day. With a recovery of about 20 to 25 per cent from softwood, this means a daily intake of from 40 to 50 tons of wood residues. Units of several times this capacity are available. Generally, all residues from bark and chunks to sawdust and shavings can be processed but the larger pieces must first be hogged.

Manufacture

The first step in charcoal production by a continuous process is the reduction of the residues to fines, usually with a maximum diameter of ½″ to ¾″ in the least dimension. The residues are introduced through an airlock into the carbonizing chamber which is maintained at a temperature of about 700°–1000° F. The off-gases are usually recovered to heat the process after an initial start-up period but they may be flared and natural gas used under some circumstaces. Excess off-gases are normally flared but could be used as fuel in a boiler. The wood is reduced to charcoal for about 15 minutes to ½ hour and is ejected from the carbonizing chamber through a second airlock and cooled.

Capital investment

Investment data for two continuous retorts processing hogged wood are given below. The third, processing mill ends on a batch basis, is included for comparison.

These figures were supplied by the equipment manufacturer in each case. In general, it appears that a minimum of $125,-

Comparison of Investment Costs

Item	Continuous 10 tons/day	Continuous 50 tons/day	Batch 20 tons/day
Buildings	$40,000	$100,000	$30,000
Equipment	80,000	325,000	80,000
Contingencies	10,000	25,000	10,000
	$130,000	$450,000	$120,000

000 plus land, utilities, and working capital is required for any continuous charcoal operation.

Marketing

From a practical standpoint, the choices in marketing of the charcoal fines produced by these plants are relatively limited. Fines can be sold to an independent charcoal briquetting plant or can be briquetted in a captive plant. The reported price for charcoal fines in California in 1963 was between $30 and $35 per ton although the U.S. Forest Service reported that the delivered price at the briquetting plant in California in 1961 was $44 per ton.

Charcoal briquetting

The increasing charcoal consumption in the United States, mentioned earlier, is essentially caused by the expansion of recreational use of charcoal in the form of briquettes. A single ownership of both charcoal producing and briquetting facilities enhances both operations. Therefore, any charcoal producing installation should be associated with a briquetting plant if at all possible.

Raw material requirements—One ton per hour appears to be the minimum operating rate for an economical charcoal briquetting plant. However, units with 2 to 3 tons capacity per hour appear to be more common.

Manufacture—Briquettes are produced by crushing the charcoal, usually by a hammer mill, mixing it with starch and water and forming in a press. The briquettes then are dried and sacked. Composition of the mixture at the time of pressing is about 73 parts charcoal, 4 parts starch, and 23 parts water.

Capital investment—Estimates for several briquetting plants, obtained from the manufacturers, are given in the table below, and include as many details as were available.

Marketing—Most of the charcoal briquettes produced are sold to jobbers for distribution. A large amount is sold to chain-type retail outlets and a limited percentage directly to local stores.

Briquette Plant—Investment in Addition to Freight, Land and Utilities

Item	Estimated costs				
	Manufacturer 1	Manufacturer 2	Manufacturer 3	Manufacturer 4	
	2 tons/hr	2 tons/hr	2 tons/hr	1–1½ tons/hr	2–3 tons/hr
Equipment	$75,000	$62,000	$.....	$123,000	$167,000
Conveyors, hoppers, bins, etc.	46,500	.....	.....	.....	.....
Buildings	72,500	.....	.....	81,000	138,000
Contingencies	19,500	.....	.....	.....	.....
Total	$213,500	$62,000	$275,000	$204,000	$305,000

References

Anonymous

1957. Charcoal production in the United States. Washington, D. C., USDA For. Serv. Div. of For. Econ. Res. 14 pp.

1961. Charcoal production, marketing, and use. Madison, Wisc., U. S. For. Prod. Lab. Rept. 2213.
1961. Charcoal briquettes sales. Raleigh, N. C., Aeroglide Corp. Inf. Bul. 402.
1962. Charcoal. FAO of the UN, Rome, Occasional Paper 2.
1963. Charcoal and charcoal briquette production in the United States, 1961. Washington, D. C., USDA For. Serv. Div. of For. Econ. and Marktg. Res. 33 pp.

Beglinger, E.
1952. Charcoal production. Madison, Wisc., U. S. For. Prod. Lab. FPL No. R1666–11.

Hempf, F. E.
1957. Production and sale of charcoal in the Northeast. Upper Darby, Pa., Northeastern For. Exp. Sta. Paper 100.

Jarvis, J. R.
1960. The wood charcoal industry in the state of Missouri. Columbia, Mo., Univ. of Missouri Eng. Ser. Bul. 48.

Kasile, J.
1962. Wood charcoal production in California for 1961. Berkeley, Calif., Pac. Southwest For. and Range Exp. Sta. Res. Note 210.

Keppler, W. E., and W. T. Huxter
1962. Feasibility guide for charcoal briquetting plant. Raleigh, N.C., Wood Prod. Ext. Sect., Sch. of For., North Carolina State College.

Pritchard, W. M.
1960. A simplified charcoal retort. For. Prod. Jour. 10(12):640–41.
1961. Simplified batch retort permits economical charcoal production. Hitchcock's Wood Working Digest 63(3):48–50.

Simmons, F. D.
1957. Guides to manufacturing and marketing charcoal in the northeastern states. Upper Darby, Pa., Northeastern For. Exp. Sta. Paper 95.

Warner, John R., and W. B. Lord
1957. The market for domestic charcoal in Wisconsin. St. Paul, Minn., Lake States For. Exp. Sta. Paper 46.

MISCELLANEOUS PRODUCTS

Sweeping compounds

The manufacture of sweeping compounds from sawdust presents a limited opportunity for sawdust utilization. Ingredients usually are sawdust, paraffin oil, powdered wax, salt, sand, and fragrance and coloring materials as desired. Proportions vary but one formula uses 30 parts sawdust, 1 part paraffin oil, 1 part salt, 10 parts sand, and a small amount of powdered wax.

The oil and wax are generally heated and the dry ingredients added to it. Mixing is done in a tumbling drum similar to a concrete mixer.

No study of markets was made. Presumably marketing would be through janitorial supply houses or jobbers. Since investment is limited and small operations are feasible, current needs are probably supplied from local sources in each market area.

Wood shavings

A good market for wood shavings exists, largely as poultry and livestock litter. Pine and true fir species are preferred in this use, and incense cedar is unacceptable. Shavings are normally baled, but occasionally may be sold in bulk.

Briquetted wood

Compressed wood fines fuel logs have been produced for many years and an established market exists. Each machine for the production of the only important product of this type requires approxi-

mately 12 tons of kiln-dried residues per day. Mill sales price of this product in Humboldt County in the fall of 1963 was $14 per ton. Markets are largely in metropolitan areas, and distance to markets is important. Merchandising is a factor that is not very well exploited by most current producers.

A potential market, just beginning to be exploited, is for recreational use. This market could perhaps be best served by smaller production units located in the market area. A process which seems to have several advantages for this approach has recently been developed by the British Columbia Research Council. Their "Fuel Log Process" uses wet sawdust as a raw material to produce a log which does not disintegrate on outside storage.

The log making machine sells for about $5,000 including royalties and can produce about 1,300 pounds of logs in eight hours. This should facilitate pilot or small plant operations although the most efficient operation would include a battery of machines. Production costs have been estimated at $20 per ton. This means that in order for the operation to compete with other processes, a special market situation must exist. It must be possible to minimize both transportation and sales costs. Areas with both summer and winter recreation and adjacent to the producer, such as near Lake Tahoe and Mt. Shasta, might meet these requirements to a high degree.

It has also been reported that a wafering machine developed for processing cattle fodder is suitable for use on wood fines. Cubes or briquettes produced by this method might also be saleable to the recreational market and compete directly with charcoal, but actual saleability and production problems and costs have not been evaluated by the author.

Use of these products as a heat source for the protection of crops has been tested in a limited way with encouraging results but the use has not been developed.

References

Anonymous

1962. Sawdust floor-sweeping compounds. Madison, Wisc., U. S. For. Prod. Lab. FPL No. 1666–14. 3 pp.

1964. Fuel log process. Vancouver, B. C., British Columbia Res. Council. 6 pp.

Ivory, E. P.

1956. Reducing sawmill waste 90 per cent in six years. For. Prod. Jour. 6(8):279–81.

Reineke, L. H.

1955. Briquets from wood waste. Madison, Wisc., U. S. For. Prod. Lab. FPL No. 1666–13. 7 pp.

APPENDIX: RESIDUE ESTIMATION

A firm contemplating the use of its processing residues must first determine and classify these residues by type and volume. This can be done in a number of ways. Estimates may be made from averages reported by industry or from studies in varying detail made at a particular operation. The outline of a very intensive study of residues developed at a particular operation, based on a materials balance, is reported by Shelton (1954). At the other extreme is the sampling of the material in the burner conveyor for a short period of time, then scaling up this sample to estimate total production. The materials balance approach requires more manpower than may be available to most operators. On the other hand, sampling and the use of industry averages may provide insufficient or erroneous answers. Several references on residue surveys are listed on page 26.

The procedure described here lies between these extremes. It is well within the capability of any firm, and yet it provides accurate information in detail adequate for sound planning of most ventures. This study was made of a firm in the California Pine Region operating two sawmills and a remanufacturing plant.

Table A-1. Log Size Frequency Distribution for the Three-month Sample Period

Bd ft class midpoint	Diam. class (inches)	Number of logs		Bd ft class midpoint	Diam. class (inches)	Number of logs	
		Mill A	Mill B			Mill A	Mill B
25	8	5	4	725	31	35	37
	9	30	9		32	32	36
75	10	56	14	775	33	29	34
	11	72	18	825	34	26	33
	12	90	22	875	35	23	31
	13	98	25	950	36	20	30
125	14	103	29	1050	37	18	28
	15	103	32		38	16	26
175	16	99	35	1150	39	15	24
	17	95	38	1250	40	13	22
225	18	91	41	1350	41	12	20
	19	86	43		42	10	15
275	20	81	45	1450	43	9	13
	21	77	47		44	7	10
325	22	72	47	1550	45	6	8
375	23	67	46		46	5	6
425	24	62	45	1650	47	4	5
475	25	58	44	1750	48	3	5
525	26	54	43	1850	49	3	4
	27	50	42		50	2	3
575	28	46	40	1950	51	1	2
625	29	43	39	2050	52	1	1
675	30	39	38				

Procedure

Sawmills—Chippable material available was estimated at each sawmill. A sample of logs was measured and followed through the headrig. Breakdown pattern for each log was recorded and slab volume determined, assuming a round cross-section but taking taper into account. The volume of individual edging pieces was estimated and an average value applied to each board edged from the sample logs. Trimming data were developed from saw spacings and from a sampling of grade trimming practices. Trim residues were assumed to be constant for all log diameters since trimming for grade in the conventional sense did not appear to be practiced. Bark volume was estimated from bark thickness and log diameter and length data. Sawdust volume was not estimated but this could be done from the available data.

Remanufacturing plant—Total chippable residues were computed on the basis of past pulpwood shipments plus an estimated 5 per cent additional now being shunted to the burner and the boiler. A rough estimate only was made of fine residues at the remanufacturing plant because fine residues are less promising than coarse residues for the manufacture of useful products. The estimate was made on the basis of computed current consumption for steam production.

Sawmill Residues Generated on a Daily Cut of 75 MBM Log Scale*

Item	Cu ft/MBM	Cu ft/day	Cu ft/240-day year
Mill A			
Chippable wood	36.9	2767.5	664,200
Bark	21.4	1605.0	385,200
Mill B			
Chippable wood	31.1	2332.5	559,800
Bark	20.0	1500.0	360,000

* Sawdust not included.

Results

The amount of chippable residues available at the sawmills depends on the species, size, and quality of the logs being cut. Log data were available for only a three-month period of 1963; they are presented in table A-1, giving log size frequency distribution. Figure 5 shows the relationship between log diameter and chippable material produced per MBM log scale. The similar relationship for bark, which did not vary noticeably between mills, is given in figure 6. Table A-2 presents the effect of differences in log diameter distributions, showing chippable and bark residual per MBM as affected by log

Table A-2. Cubic Feet of Residual per MBM as Affected by Log Diameter

Bd ft class midpoint	Diam. class (inches)	Chippable wood		Bark, both mills	Bd ft class midpoint	Diam. class (inches)	Chippable wood		Bark, both mills
		Mill A	Mill B				Mill A	Mill B	
25	8			33.0	725	31	23.0	28.7	17.1
	9			30.2		32	22.2	27.8	17.1
75	10			27.7	775	33	21.5	26.9	17.1
	11			25.6	825	34	21.0	26.1	17.1
	12	78.5		23.6	875	35	20.6	25.4	17.1
	13	71.0		20.8	950	36	20.1	24.7	17.1
125	14	64.3		20.3	1050	37	19.7	24.0	17.1
	15	58.5	74.2	19.0		38	19.4	23.5	17.1
175	16	53.8	66.8	17.7	1150	39	19.1	22.8	17.1
	17	49.3	61.0	16.6	1250	40	18.8	22.3	17.1
225	18	46.0	55.6	15.8	1350	41	18.6	21.7	17.1
	19	42.2	51.4	15.2		42	18.3	21.3	17.1
275	20	39.2	47.6	15.0	1450	43	18.2	20.8	17.1
	21	36.6	44.5	14.9		44	18.1	20.4	17.1
325	22	34.3	41.7	15.0	1550	45	18.0	20.0	17.1
375	23	32.2	39.6	15.3		46	17.9	19.5	17.1
425	24	30.5	37.9	15.7	1650	47	17.8	19.3	17.1
475	25	28.8	36.2	16.2	1750	48	17.7	19.0	17.1
525	26	27.5	34.7	16.5	1850	49	17.6	18.7	17.1
	27	26.7	33.2	16.8		50	17.5	18.4	17.1
575	28	25.5	31.9	17.0	1950	51	17.4	18.0	17.1
625	29	24.6	30.8	17.0	2050	52	17.3	17.7	17.1
675	30	23.7	29.6	17.1					

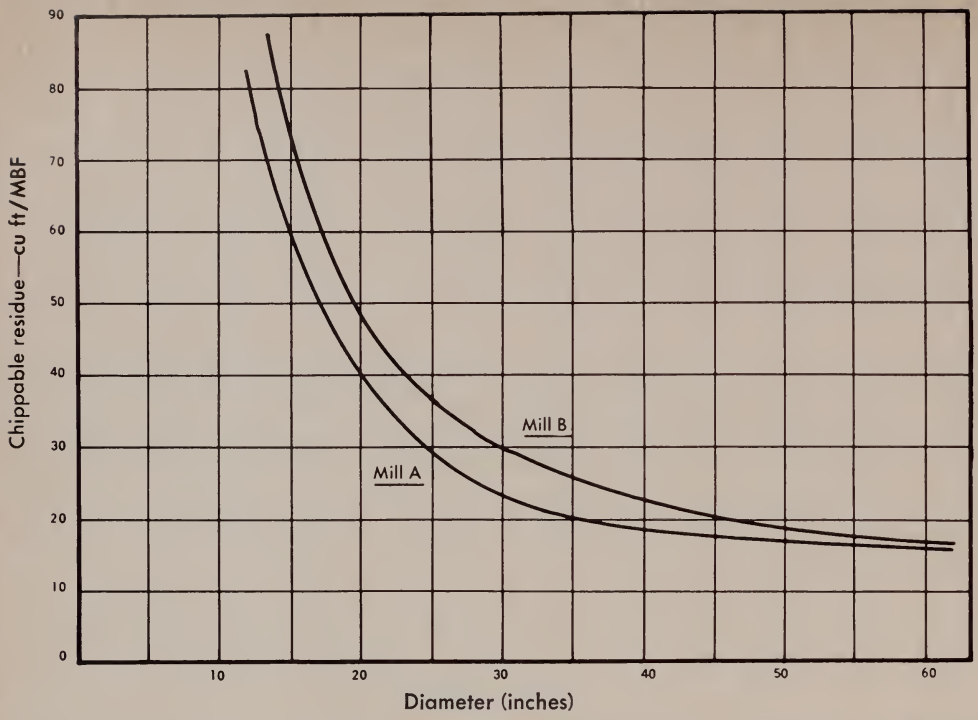


Fig. 5. Cubic feet of chippable wood residual per MBM log scale from logs of various diameters.

diameter. If a significant shift in diameters of logs were to occur, the amount of residues anticipated to be available should be adjusted according to the table.

A daily cut of 75 MBM/day would produce the volumes of residues shown in the table "Cubic Feet of Residual per MBM as Affected by Log Diameter" on page 23.

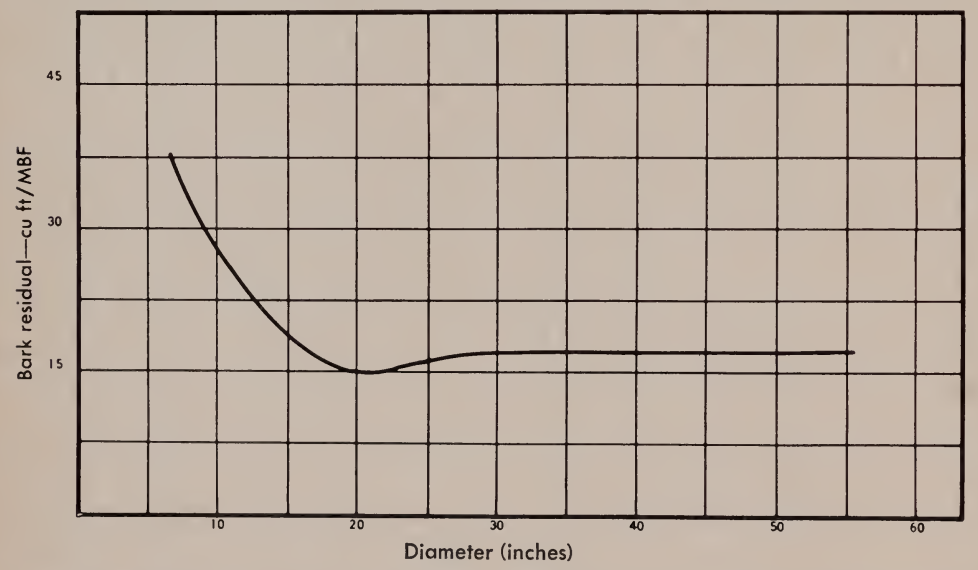


Fig. 6. Cubic feet of bark residual per MBM log scale from logs of various diameters (both mills A and B).

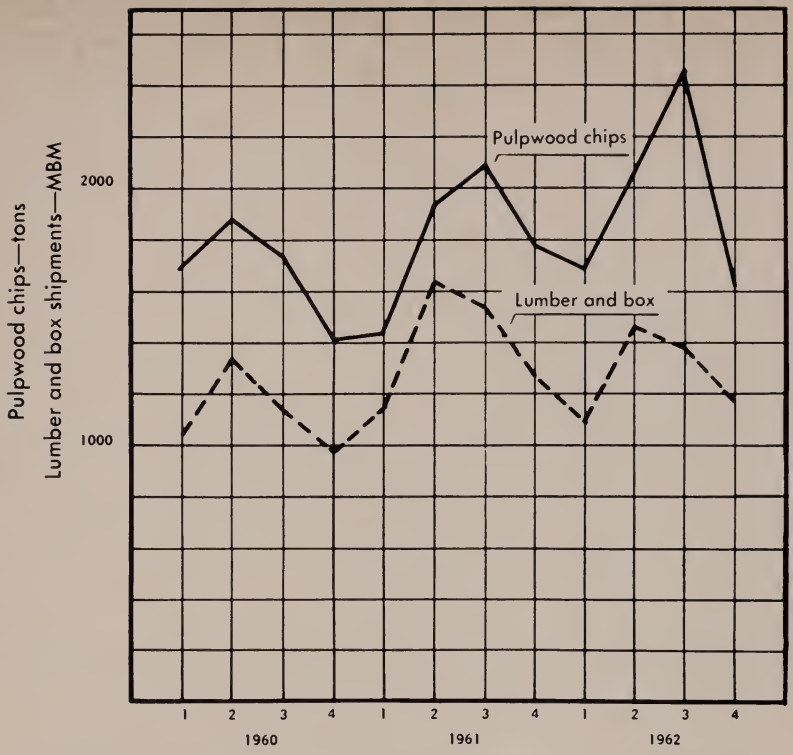


Fig. 7. Shipment of products—remanufacturing plant (quarterly averages).

REMANUFACTURING RESIDUES

Figure 7 presents the pulpwood shipments from the plants and the total lumber and box shipments for the past three years. There appears to be a fair degree of correlation between these curves. On this basis, a ratio of 0.147 ton, or 294 pounds, of chippable wood produced per MBM of wood products shipped was established.[3] Fine residues (sawdust and shavings), now used for fuel, were estimated to total 0. 154 ton per MBM.

Remanufacturing plant residues generated on a daily production of 200 MBM

	Per MBM	*Per day*	*Per 240-day year*
Chippable wood . . .	19.7 cu ft	3944.0 cu ft	946,560 cu ft
Sawdust & shavings . .	308 lbs	61,600 lbs	18,784,000 lbs

Discussion

The residues have not been separated by species. The species composition would be approximately related to the ratio of species processed for lumber. The fluctuations in species processed in the past are given in figure 8. The utility and problems connected with the use of different species vary, depending on the product made. If a utilization plan is adopted which is sensitive to species differences, considerable care will need to be exercised in planning of timber purchases and logging operations to maintain the desired balance. As is shown in the table giving chippable and bark residual per MBM as affected by log diameter, a change in log diameters processed significantly affects the volume of residues available. If a shift does occur in log diameters processed, residue projections should be adjusted in accordance with this table.

[3] There are approximately 3,000 pounds of wood material per 200 cu ft unit of hogged wood and approximately 1,600 pounds per cord unit of trim ends.

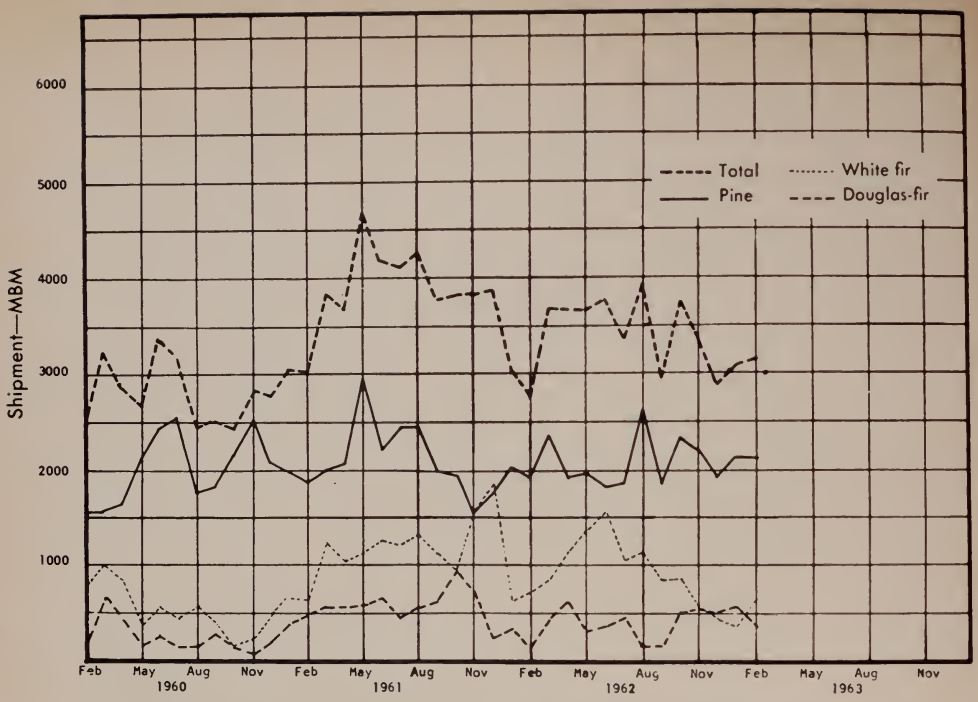


Fig. 8. Monthly lumber shipments by species—remanufacturing plant.

Selected bibliography on residue surveys

Anonymous
1957. Conversion factors for Pacific Northwest forest products. Univ. of Washington Inst. of For. Prod.

Batori, S. M.
1957. Wood equivalents—logs to boards, plywoods, and products from residuals. Amer. Soc. Mech. Engrs. Paper 57–SA–88. 8 pp.

Carpenter, R. D.
1950. Amount of chippable waste at Southern Pine sawmills. New Orleans, La., Southern For. Exp. Sta., Occasional Paper 115.

Corder, S. E.
1964. Mill residues in Jackson and Josephine counties in 1962. Oregon State Univ. For. Res. Lab. Inf. Cir. 19.

May, R. H., and L. N. Ericksen
1955. Wood residue from primary wood-using industries in California. Calif. For. & Range Exp. Sta. Tech. Paper 13.

Sarvis, J. C.
1959. Bark utilization study. Portland, Ore., West Pine Assn. Res. Note 7.221. 11 pp.

Shelton, N. T.
1954. Chip yield and materials balance as related to log size in the California pine and fir region. For. Prod. Jour. 6(8):281–84.

To simplify the information, it is sometimes necessary to use trade names of products or equipment. No endorsement of named products is intended nor is criticism implied of similar products not mentioned.

7½m-10,'65 (F5045) J.F.